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Influence of a Publication Performance Indicator on Danish Research Production and Citation Impact 2000-12

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Abstract. This paper analyses the patterns of Danish research productivity, citation impact and (inter)national collaboration across document types 2000-2012, prior to and after the introduction of the Norwegian publication point-based performance indicator 2008/09. Document types analysed are: research articles; conference proceedings papers excluding meeting abstracts; and review articles. The Web of Science citation index (WoS) combined with the Danish Research & Innovation Agency's basic statistics is used for data collection and analyses. Findings demonstrate that the overall productivity and citation impact steadily increases over the entire period, regardless the introduction of the performance indicator. The collaboration ratio between purely Danish and internationally cooperated research articles remains stable during the period, the number of collaborative countries increases while the ratio as well as number of countries decline for proceedings papers. The citation impact of internationally cooperated research articles increases since 2009 but decreases for proceedings papers; also their productivity declines slightly since 2009. From the same point in time the ratio between proceedings papers and research articles starts declining in WoS corresponding to actual developments observed in the Research Agency dataset. Since 2009 the WoS coverage of proceedings papers as such is declining. The positive growth in research articles derives from the Science and Technology fields published in prestigious Level 2 journals; the Level 1 article growth derives primarily from S&T, the Social Sciences and Medicine. Three of the eight Danish universities alter their research publication profiles since 2009. The introduction of the publication performance model is regarded the accelerator of these processes in recent years.

Keywords

Publication performance indicator; citation analyses; Publication patterns; Denmark; Research articles; Review articles; Proceedings papers

Introduction

The rationale behind national research assessments is to observe and understand the patterns of research production monitored through research publications in a country. In addition research impact measures are applied in order to assess the influence the research produced may have on later research and development activities. As part of the research monitoring measures, and to allocate public research funding, the so-called 'Norwegian publication performance' indicator or model based on assigned publication points was introduced in 2008/09 into the Danish academic landscape (Schneider, 2009). The motivation behind the present investigation is to observe the kind of influence the indicator model has had on the

Danish research production nationally as well at university level and on the national citation impact. Consequently, the investigation monitors the research development during the periods before and after the introduction 2008, that is, from 2000 to 2007 and 2008-2012.

Commonly monitoring of institutional and national productivity and citation impact are limited to peer reviewed journal articles (van Raan, 1999; 2005; Moed, 2005). The performance indicator model also takes into account peer reviewed proceedings papers, albeit hitherto assigning less scoring points to this publication channel. Thus, we have included this document type as well in the present investigation.

When the performance indicator model was started up 2009 68 groups of researchers from the Danish universities were established to list and assign points to peer reviewed journals, publishers and conferences that publish scientific material authored by Danish academics for the year 2008. These groups have until now continued to assess the publication channels. The performance indicator takes into account published peer reviewed research and review articles, monographs, anthology and proceedings papers. In the publication period 2008-2012 proceedings (and anthology) papers were assigned fewer points (.75) than journal articles (1.0 in Level 1 journals and 3.0 in Level 2 journals, i.e. the leading journals of a field as judged by the relevant researcher group and covering maximum 20 % of the field journal output). From 2013 proceedings papers are supposed to receive similar points as articles, depending on the level of the conference, as assessed by the relevant group. For each document the points are fractionalized (min. 0.1) according to number of collaborating universities and institutions; then cumulated per institution. The model encourages collaboration by multiplying the institutional fraction obtained by 1.25 in collaborative publications. Each of the 68 groups represents an academic field or specialty.

Since 2009 the past year's research output has been assigned points annually that are used to distribute a substantial portion of public research funding among the universities the following year. Only the cumulated results are publicly available per university and major academic area, such as the Humanities or Medicine/Health sciences (Forskningsstyrelsen, 2013); the intermediate or more detailed publication point distributions and document lists per unit and department are not publicly accessible. This is in difference to Norway where no multiplication of fractions takes place and all the documents and their point assignments are transparent as well as publicly accessible through an open access database (Sivertsen, 2010). In Belgium the Flemish BOF-key applies whole counting at the institutional level (Debackere & Glänzel, 2004; Engels, Ossenblok & Spruyt, 2012).

With respect to the publication performance indicator a major underlying idea was to encourage publishing in so-called 'Level 2' journals when implemented in Norway (Aagaard & Schneider, 2012). This has been studied in Norway and results demonstrate a substantial increase of 55 % 2005-09 for articles in Level 2 journals (Sivertsen, 2010; Sivertsen & Schneider, 2012). The Belgian experience for the social sciences and humanities is analysed by Ossenblok, Engels and Sivertsen (2012). The influence of peer reviewed proceedings papers on citation performance has not been studied extensively (Butler & Visser, 2006; Ingwersen & Larsen, 2013; Ingwersen et al., 2013) – and then mostly in relation to particular fields like computer science (He & Guan, 2008; Wainer et al., 2011). They have not been studied at all in relation to performance indicator models like the Danish/Norwegian one based on publication points.

The present analysis extends the study by Ingwersen & Larsen (2013), which looked at the impact of the Danish university mergers 2006 and the performance indicator at national level covering the period 2000-2010, by in addition to investigate the patterns of research productivity and citation impact across document types prior to and after the introduction of the Norwegian performance system 2008/09, covering the period 2000 to 2012. Further, the productivity patterns in the major research areas (Science & Technology, Medicine and the

Social Sciences) as well as for the eight Danish universities are analysed in order to observe if the research production profiles have changed after 2008.

Due to the fractionalization principle of the performance system one might expect a decrease in institutional collaboration after 2009 at international as well national levels in all document types. By some (science and technical) universities fractionalisation was seen to penalize international collaboration by the research communities. From the perspective of Humanities and some social science fields the entire measurement system was regarded as an attack on the freedom of research and many critical opinions have been posted on academic blogs (e.g. <http://professorvaelde.blogspot.com>; <http://www.forskeren.dk>). From the government perspective the hopes were to reinforce an increase of the overall Danish research production and citation impact owing to better research quality with the performance system as incentive.

Motivated by the aforementioned assumptions the present investigation has the following three research questions:

1. Did the introduction 2008-09 of the publication performance indicator for peer reviewed research and review articles and proceedings papers (but excluding the humanities and monographs) alter the overall Danish productivity patterns, citation impact or (inter)national collaboration in the following years – and compared to the preceding period?
2. Did the performance indicator alter the research productivity patterns in Science & Technology, Medicine and Social Sciences after 2008?
3. Did the performance indicator alter the research productivity patterns in the individual Danish universities after 2008?

It is important to stress two influential variables: (1) Research funding and (2) University structure. With respect to funding, the Danish public funding of universities and research has not declined as a result of the economic crisis from 2008. It is fairly constant at a 0.9-1.1 % of the national BNP and its potential influence on productivity and research quality may be regarded as neutral. As regards the university landscape in Denmark the most crucial event was the university mergers that took place 2006, reducing many smaller universities and research centres to eight larger universities, with University of Copenhagen as the largest and most prestigious university. According to the study by Ingwersen & Larsen (2013) the mergers did not seem influential in productivity or citation impact. During the period 2000-2010 both productivity and impact of research articles constantly grew, and a decrease was only detected for proceedings papers in later years. Consequently, it would be interesting to discern if collaboration patterns, particular universities and single academic fields contribute to the observed trends.

From a methodological standpoint the investigation makes use of the Web of Science (WoS) citation indexes SCI, SSCI, CPCI-S and CPCI-SSH (Thomson-Reuters) as basis for the annual analyses and covers a period of 14 years: 2000-2013. Monographic material and the Humanities fields are not explicitly dealt with in the investigation owing to the language bias in WoS. However, some humanistic documents are involved by the application of CPCI-SSH. For comparative reasons the point-based performance indicator statistics 2009-13 (covering 2008-12) are included since they demonstrate the real number of research documents published in Denmark (Forskningssstyrelsen, 2013) across universities and major research areas.

The paper is organized as follows. Data collection procedures and analysis methods including three collaboration indicators are described. This is followed by three sections on findings. One section deals with the overall development of productivity 2000-2012, citations

to and impact of Danish research over the period 2000-2011 across research articles, proceedings papers¹ and review articles. This is followed by a section on (inter)national cooperation across document types and citation impact developments. Analyses of the average number of collaborating countries and number of Danish research institutions across document types provide indications of publication behaviour that might have been influenced by the introduction of the publication performance model. The third section compares statistics from the development of the system to the WoS-based observations. This includes the distribution 2008-12 of research publications over the three major academic areas and the eight Danish universities. Discussion and conclusion sections close the paper.

Methodology

The data collection was carried out in WoS on November 6-10, 2013 on Science Citation Index (SCI), Social Science Citation Index (SSCI), Conference Proceedings Citation Indexes for Science (CPCI-S) and Social Science and Humanities (CPCI-SSH). For each year the Danish share of WoS indexed materials was observed to detect any anomalies in database developments. Nothing particular was detected: the Danish world share remains rather constant at .80 % 2000-08; then it increases to almost 1.0 %.

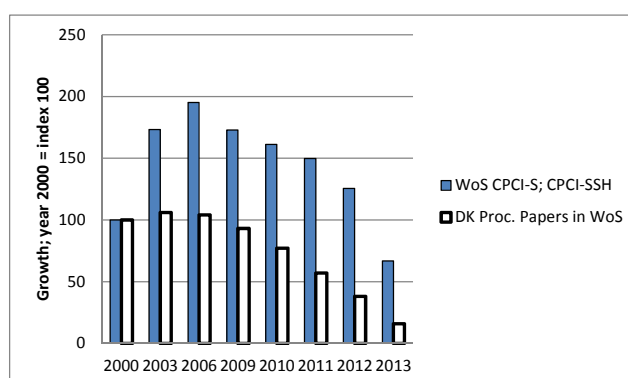


Fig. 1. Growth of CPCI-S, CPCI-SSH 2000-2013 and Danish proceedings papers (WoS, November 2013)

Research quality is measured in terms of citation impact. The citation window is kept at three years. This implies that 2011 is the last year with a workable three-year citation window (2011-2013). Since the analysis period is November 6-10 the actual citation rates and impact scores are given including the initial date as well as an estimate calculated by a factor of 6/5 of the actual rate. Citation and publication analyses are studied for each document type separately: research articles; review articles; proceedings papers. ‘Other’ types of documents that include meeting abstracts, editorials, book reviews, letters to editors, errata, etc. are taken into account but omitted from further analysis, which solely concerns the former three types. The WoS document category ‘proceedings papers’ is used to retrieve peer reviewed proceedings papers. They derive from the two CPCIs as well as from the original citation indexes (SCI and SSCI). In the latter case they are also commonly tagged by the category ‘article’; but in the CPCIs there exists a partial overlap between the two document categories, which changes over time. Also over time, the two conference citation indexes display a great variety in coverage that actually declines since 2006, Fig. 1. The discussion section includes an analysis of the WoS coverage of Danish and world proceedings papers in the CPCIs, compared to the actual volume of proceedings papers during the period 2008-12 provided by

¹ Proceedings papers include this WoS document category and exclude the category ‘Meeting Abstracts’.

the Danish Research Agency. In order to avoid the said overlap in the WoS analysis between the document categories, foremost between research articles and proceedings papers, all documents indexed by both tags were kept as proceedings papers and thus excluded from the article category. Samples drawn from the overlap showed that such documents are indeed conference papers or contributions from proceedings but published in serial or thematic journal issues; thus the exclusion from the research article category.

Further, the ratio of proceedings papers vs. research articles is calculated per annum. These two publication types are regarded the channels that directly communicate scientific knowledge; review articles are seen as submissions that summarize already published knowledge. In relation to (inter)national cooperation the investigation operates with the following indicators:

- 1) *International cooperation ratio*, i.e., the ratio (between 0.0 and 1.0) of documents that are published in collaboration between Denmark and at least one other country. This ratio is calculated annually for research articles and proceedings papers separately.
- 2) *Average Number of countries per internationally collaborated document*;
- 3) *Average number of Danish institutions collaborating per document* within the set of purely national Danish publications for each document type.

In order to divide each annual set of research articles and proceedings papers into a purely national set of publications and a set of internationally authored documents for each type the analytic tools provided by WoS were applied to list, select and retrieve the documents from the collaborating countries to form a separate set of records, named the international cooperative set. The number of individual countries was detected in this set. The total number of documents containing at least one country was calculated by aggregating the number of documents assigned each country in the set. This aggregated number of documents was then subtracted by the national set and then divided by the number of documents in the international cooperative set to produce indicator (2).

The set of purely national Danish publications in a document type was retrieved by means of Boolean NOT logic of the international cooperative set on the initial set of that document type. The resulting purely Danish set was then analyzed by the Analyze Result tool of WoS for each document type with respect to the metadata category of 'Organizations Enhanced'. The total number of documents containing at least one institutional name was calculated by aggregating the number of documents assigned each 'Organization Enhanced' in the set. This aggregated number of documents was then divided by the number of documents in the national Danish set to produce indicator (3). It is important to stress that in this calculation name form control of institutions is not necessary. Since only one name form of each affiliated institution is commonly assigned each document, logic dictates that this calculation involving institutional names signifies the average number of *different* institutions collaborating per document. Thus, the analysis does not inform about the number of different unique institutions that collaborate. Indicators (2) and (3) were calculated for the eight selected years 2001; 2003; 2006; 2008-2012. Citation impact for each document type divided into purely national and international collaborative sets was calculated for the seven selected years 2001; 2003; 2006; 2008-2011. Owing to lack of name form control citation impact at university level was not calculated in the present investigation.

In case of sets too large for WoS to handle when generating online citation reports, i.e. sets above 10,000 items, the set was logically divided into subsets according to the indicator (2) method above; subsequently the analysis results were aggregated. The Danish research article sets from 2010 to present constitute such large sets (Table 1). In total the analyses deal with almost 172,000 source documents and 960,000 citations.

The annual statistics from the performance indicator model 2008-12 (Forskningsstyrelsen, 2013) was used to form new descriptive publication statistics of the three document types, the eight universities as well as to the overall academic areas of Science & Technology, Social Sciences and the Medicine/Health Sciences covering the period 2008-2012. For 2008 the number of publications was estimated from the assigned points. The statistics cover more publications than indexed by WoS, and they include overlaps between the Danish universities. Nevertheless, the *trends* can be compared between our findings through WoS and those observed by the agency.

Findings

Table 1 displays the annual number of Danish research publications indexed by WoS 2000-2012 including the three dominant document types, and the corresponding citation volumes. Figures 2-3 provide the corresponding citation impact development over the entire period.

The general trend for research articles, Table 1, is a steady increase of productivity over the entire period. For proceedings papers the years 2001, 2004 and 2006 display negative growth. The highest productivity is reached in 2007. From 2008 and onwards the productivity, according to WoS indexing, is declining fast. For review articles three years 2001, 2007 and 2010 demonstrate negative growth. The major type of documents in the document category 'Other types' consists of 'Meeting abstracts' throughout the period.

Table 1. Annual Danish research publications and citations 2000-2012 with three year citation windows in (parenthesis); 2011 (2011-13) is estimated (WoS, November 2013)

	2000 (2000-02)		2001 (2001-03)		2002 (2002-04)		2003 (2003-05)		2004 (2004-06)		2005 (2005-07)		2006 (2006-08)	
<i>Document types</i>	Publ.	Citations	Publ.	Citations	Publ.	Citations	Publ.	Citations	Publ.	Citations	Publ.	Citations	Publ.	Citations
Research articles	6712	40687	6891	42950	6772	44136	7079	51972	7383	53582	7588	58928	7988	60655
Proc. Papers	1596	3208	1479	3255	1489	3116	1696	3539	1595	3887	1777	5146	1660	4634
Review articles	341	4458	304	4696	357	3838	351	5805	446	6817	472	7291	558	8656
Other types:	1523	1272	1262	927	1645	953	1620	1022	2042	1093	2412	1507	2432	1568
Total types:	10172	49625	9936	51828	10263	52043	10746	62338	11466	65379	12249	72872	12638	75513
Online:	10172		9936		10263		10746		11466		12249		12638	

	2007 (2007-09)		2008 (2008-10)		2009 (2009-11)		2010 (2010-12)		2011 (2011-13) (2011-13)		2012
<i>Document types</i>	Publ.	Citations	Publ.	Citations	Publ.	Citations	Publ.	Citations	Publ.	Citations	Publ.
Research articles	8532	69693	9178	78130	9840	83799	10931	98017	12424	96523	115827
Proc. Papers	1852	4745	1538	4553	1488	4422	1269	3177	956	1348	1617
Review articles	545	9605	651	12846	760	13892	721	12366	814	11339	13606
Other types:	2755	2023	2760	1910	3111	2100	2869	2958	2847	3067	3680
Total types:	13684	86066	14127	97439	15199	104213	15790	116518	17041	112277	134730
Online:	13684		14127		15199		15790		17041		18045

For citations given to research articles the growth is constantly very positive; for review articles smaller variations are observed during the period although the general trend is positive. This includes the 2011 research and review articles cited 2011-13, with citation volume estimated for the entire year 2013. The same negative growth observed for productivity of proceedings papers is observed for their citations.

Fig. 2 shows the annual ratio of proceedings papers vs. research & review articles to the left, for WoS covering the entire period compared to similar ratios according to the Danish Research Agency for 2008-2012 (Forskningsstyrelsen, 2013). The right-hand side demonstrates the cumulated 2-year citation impact for research & review articles combined (similar to a diachronic journal impact) as well as for proceedings papers separately. The WoS proceedings paper *ratio* illustrates the same trend as shown for the productivity, Table 1, with a definitive decline from 2008 in WoS. Also the Agency statistics demonstrate a similar negative trend from 2009. While the citation impact is growing to 2.96 in 2008-09 for proceedings papers, with a significant drop in 2010-11 to 2.15 (estimated), the impact for

journal-based publications (Res.art.+Rev.art.) is constantly increasing including 2010-11, reaching an impact score of 9.64.

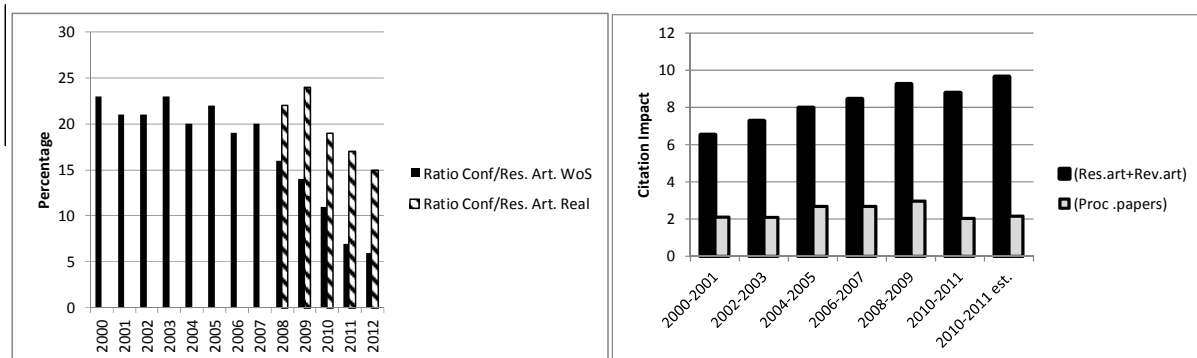


Fig. 2. Annual ratios in percentage of Danish proceedings papers vs. research & review articles, from WoS and Danish Research Agency 2008-11 (left); 3-year citation impact development for research articles & review articles combined vs. proceedings papers (right)(WoS, November 2013)

The diagram, Fig. 3 (left), demonstrates the detailed annual impact trends for the different document categories. One observes a drastic drop in impact for review articles in 2010 almost to the 2003-06 level. The *proceedings papers* are dropping in impact from 2009. However, the *research articles* constantly increase their citation impact score including 2011 (estimated), thus compensating the national Danish average citation impact (Total types DK) that is constantly rising during the entire analysis period.

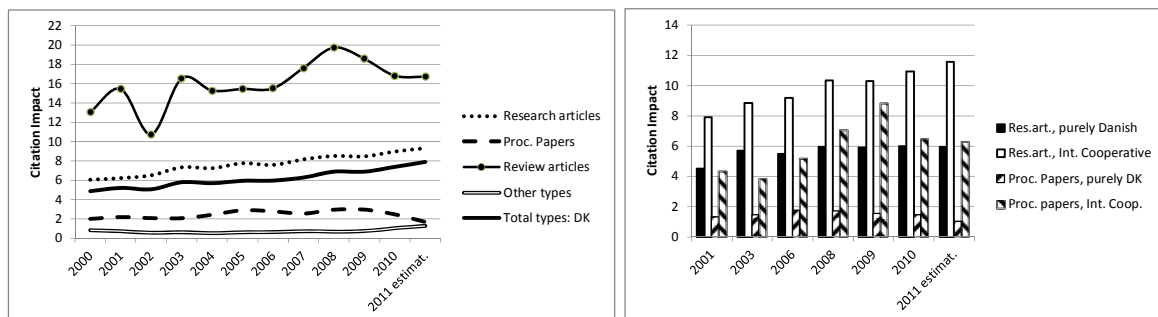


Fig. 3. Annual development of Danish citation impact to publications 2000-2011 with three-year citation window (left). Citation impact in seven selected years for research articles and proceedings papers, purely Danish vs. international cooperation (right)(WoS, November 2013).

(Inter)national cooperation, document types and citation impact

Fig. 3 (right) demonstrates the citation impact obtained by the research articles and proceedings papers published by Danish institutions only or authored in international collaboration with other nations, as indexed by WoS. The impact of the *research articles* made in international collaboration is continuously substantially higher (almost the double) than that received by purely Danish publications, the latter staying level from 2008. In addition, the international cooperative research articles demonstrate a steady impact growth. Notably, the increase simply continues regardless the introduction of the Norwegian performance indicator system in 2008/09.

In contrast, the drop 2010-11 in citation impact for the Danish *proceedings papers*, Fig. 3 (left), derives from a marked decline in the impact received by the international Proceedings publications those two recent years – as well as from the purely Danish Proceedings papers. The latter set of documents starts losing impact already in 2006 (right).

For research articles the total *number of unique countries* with which Denmark is collaborating increases steadily over the seven selected years, Table 2: from 103 countries in 2001 to 152 countries in 2012. At the same time the number of countries for *proceedings papers* reaches a peak in 2010; it drops heavily in 2011-12. This drop coincides with the decline for proceedings paper productivity according to WoS, shown in Table 1 above. Table 2 demonstrates that already from 2008 a decrease initiates *primarily* among the internationally collaborative papers according to WoS indexing, decreasing dramatically from 529 to 370 items and further down to 92 proceedings papers. From 2010 also the volume of Danish authorship proceedings papers diminishes. Although the indexing of this document type in WoS is declining, Fig. 1, the trend is real as demonstrated by the Agency's data of actual Danish production, Fig. 2, left-hand side.

Table 2. Development of international cooperation, number of cooperating countries and purely Danish authorship across document types during eight selected years (WoS, November 2013)

<i>Research Articles</i>								
	2001	2003	2006	2008	2009	2010	2011	2012
<i>Purely Danish authorship</i>	3375	3396	3453	3821	4011	4349	4993	5280
<i>Int. Coop. Authorship</i>	3516	3683	4535	5357	5829	6582	7431	8296
Total no. of documents	6891	7079	7988	9178	9840	10931	12424	13576
<i>Number of countries</i>	103	120	127	125	137	137	135	148
<i>Proceedings Papers</i>								
<i>Purely Danish authorship</i>	1031	1201	1131	1168	1189	1003	828	774
<i>Int. Coop. Authorship</i>	448	495	529	370	299	266	128	92
Total no. of documents	1479	1696	1660	1538	1488	1269	956	866
<i>Number of countries</i>	67	65	57	71	61	85	49	42

Fig. 4 displays the *international cooperation ratio* (indicator 1), the *average number of countries* collaborating including Denmark in the Danish/international research publications (indicator 2) and the *average number of Danish institutions* collaborating per document within the set of purely Danish publications (indicator 3) for research articles (left) and proceedings papers (right).

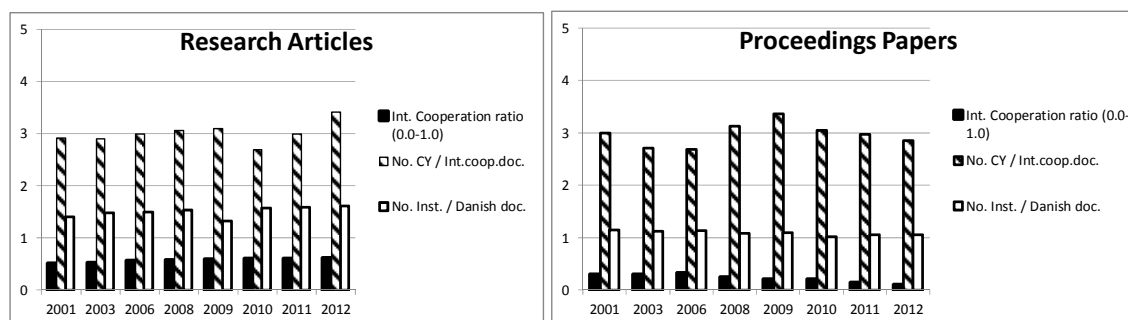


Fig. 4. International cooperation ratio (0.0 – 1.0), average number of countries collaborating in Danish publications and mean number of Danish institutions collaborating per purely Danish publications. Research articles (left); Proceedings papers (right)(WoS, November 2013)

According to the WoS indexing the *international cooperation ratio* is stable around .60 for research articles during the period (left) whilst declining from .30 to .11 for the proceedings papers since 2006 (right). For both document types USA constitutes the dominating partner for Danish research institutions and its share does indeed increase from 14 % in 2001 to almost 18 % in 2012 for the research articles and centres on 4.5 % for proceedings papers (figures not shown in tables/diagrams).

For research articles the *average number of countries* per document cooperating with Denmark (indicator 2) declines in 2010 but increases continuously since then. Also in 2010 a decline starts for proceedings papers, but continues to drop into 2012. The performance indicator model may have had a negative (perceptive) effect at its introduction 2008-09, which has turned positive in recent years for research articles, probably affected positively by the multiplication factor for cooperation and negatively by the fractionalization, in particular as concerns proceedings papers that are assigned less performance scores.

Indicator 3 (Danish collaborating institutions per document), Fig. 4, demonstrates constant average scores at 1.5 institutions per uniquely Danish research article (left), again except for 2010, and with a slight decrease to 1.05 collaborating institutions for the purely Danish proceedings paper documents (right).

Comparative statistics of actual publications 2008-12 and WoS trends

Fig. 5 demonstrates extracts from the publication statistics published by the Danish Research & Innovation Agency (Forskningsstyrelsen, 2013) for the publication years 2008-2012 associated with the performance indicator scores. The notion 'Papers' covers all proceedings papers and some book anthology papers or chapters, in particular in the Social Sciences. Humanities publications are omitted from the analyses.

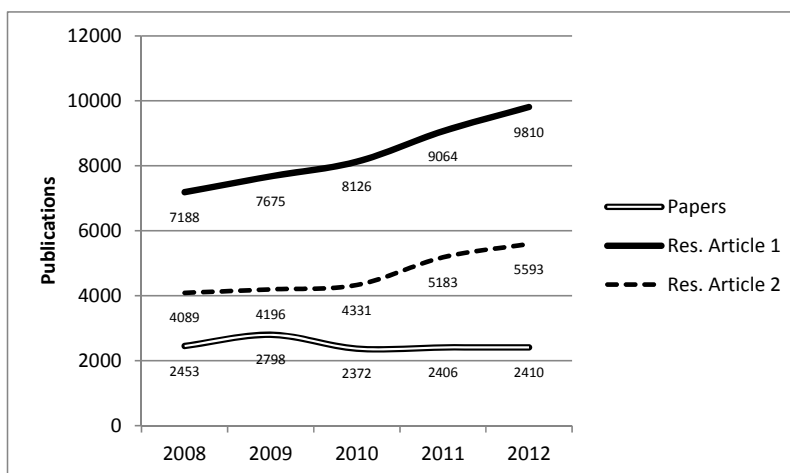


Fig. 5. The development of journal articles, Levels 1 and 2, and papers published in proceedings and anthologies; scores from 2008 are estimated (from Forskningsstyrelsen, 2013).

Developments in the three academic areas

In particular, Denmark is highly productive with respect to *Level 1 articles* (the most leading publication vehicle); their growth is primarily caused by a 37 % increase in the Social Sciences, 24 % in Medicine and 29 % in S&T, see also Diagram 6. For *Level 2 articles* a 46 % increase is made in the Sciences & Technology area over the four years 2009-12, that is, since the introduction of the performance indicator system. For Medicine the growth is only 16.4 % but 22.7 % for the Social Science fields during the same time. Fig. 6 demonstrates that the growth in the S&T fields starts in 2010 for both level types of research articles, like for

Level 2 articles in the Social Sciences, whilst the increase is quite immediate for both types of research articles in Medicine. This delay in S&T and Social Science can probably be regarded as a kind of ‘incubation time’ for researchers in those fields to adjust to the indicator system. In Medicine researchers act faster to change in the conditions and incentives for publication production for all the three document types.

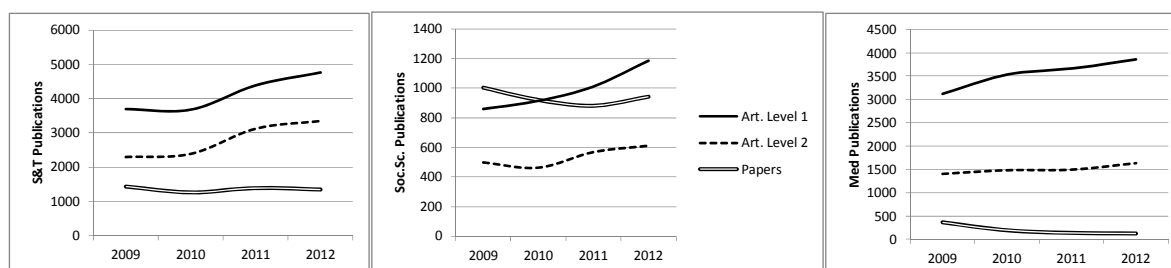


Fig. 6. The development of journal articles, Levels 1 and 2, and papers published in proceedings and anthologies in Science & Technology (left), Social Science (middle) and Medicine (right). (From Forskningsstyrelsen, 2013).

For actual proceedings (and anthology) papers the general trend, Fig. 5, is slightly negative from 2009 with Medicine, Fig. 6, as the dominant area in decline (-66 %, although for a small population) and the Social Sciences as well as S&T each with -6 %. This decline coincide with a decline observed in the WoS indexing space for the same period, Tables 1-2 and Fig. 2, but is much less pronounced than observed in WoS. One should notice the developments of the Social Science Level 1 articles vs. proceedings papers, with the former as the dominating vehicle of research output since 2010.

Developments in the eight Danish universities

Figures 7-8 display the distributions of the three document types across the eight Danish universities 2009-12; their university profiles, so to speak. In the distributions the Aalborg, Aarhus, Copenhagen and Southern universities constitute large universal universities, with research in all the three major academic areas as well as in the Humanities. The other four universities analysed are specialized. Roskilde University specializes in certain S&T disciplines, and some Humanities and Social Science disciplines. According to Fig. 7 the development for Level 1 articles (left-hand side) is rather smooth for the small specialized universities as well as Aarhus University. The Technical University is losing ground slightly since 2010 while University of Copenhagen constantly has lost somewhat more productivity since 2009 (from 38.6 % to 35.3 %). University of Southern Denmark and Aalborg University demonstrate growing shares of Level 1 articles through the period.

Fig. 7, right-hand side, on Level 2 article distributions shows more movements. In 2010 one observes an increase by Aarhus University and the Technical University. Like for Level 1 articles Copenhagen University has diminished its contribution towards 2012, from 39.8 % in 2009 to 36.8 % in 2012. Like for level 1 articles University of Southern Denmark increases its Level 2 article share in 2011-2012. The proportions of university contributions across the two article types are quite similar.

Fig. 8 displays a quite different pattern for proceedings and anthology papers. University of Copenhagen drops its contributions to these types quite substantially, from 20.8 % to 12.8 % over the four-year period. Also University of Southern Denmark decreases its output (from 9.3 % to 4.3 %). The universities of Aalborg, Roskilde and the Technical University increase their output, foremost Aalborg from 20.4 % to 26.3 %. Since the overall number of papers drops (see the N values, Fig. 8), the more stable institutions like Aarhus University and

Copenhagen Business School both contribute proportionally to the decrease in actual number of documents.

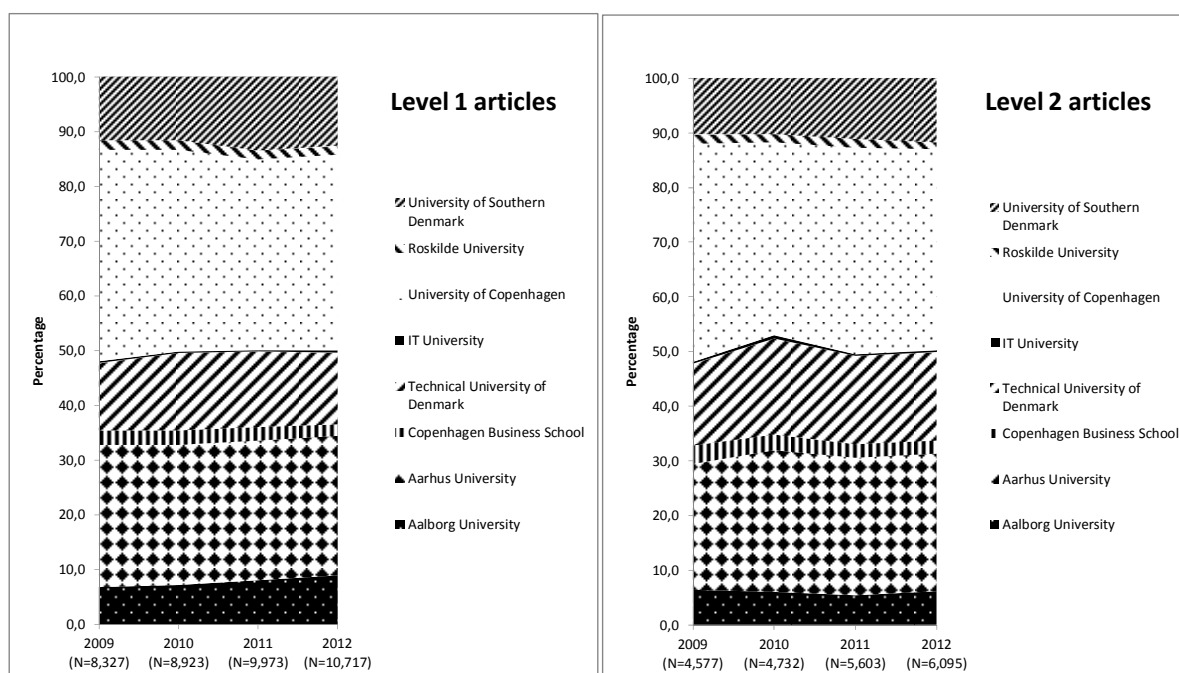


Fig. 7. Danish university contributions to Level 1 (left) and 2 articles (right) 2009-12. (Forskningsstyrelsen, November 2013)

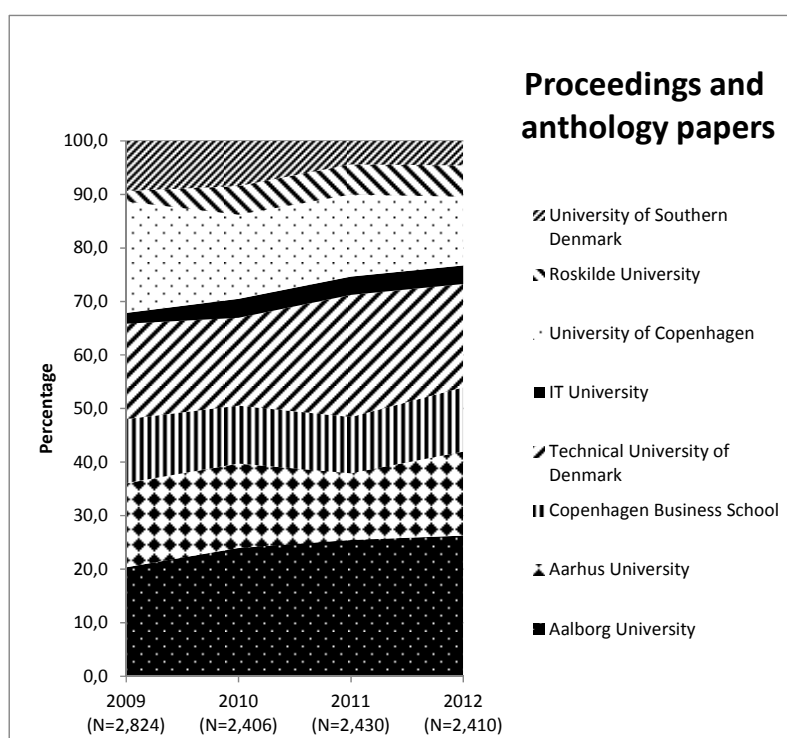


Fig. 8. Danish university contributions to proceedings and anthology papers 2009-12. (Forskningsstyrelsen, November 2013)

Discussion

Research question one on effects of the performance indicator on productivity and impact

In research question 1 we asked if the introduction of the performance indicator 2008-09 did alter the productivity and/or citation impact for Danish academic research (excluding the humanities and monographs) in the following years, compared to the period immediately prior to the introduction?

The answer is yes – in a positive as well as negative sense.

The performance system does seem to influence and reinforce the already active and positive developments in *research article production and impact*, Table 1 and Figures 2-3. The indicator has encouraged researchers to publish articles through Level 2 journals, owing to the assignment of higher scores, Fig. 5. With respect to review articles the developments are rather variable across the period; it is hence not definitive to state that the performance assessment system is causing the recent impact drop from 2009 for this document type. The quality of the review articles are simply not recognized at the same high level as in the years 2007-08.

However, indeed we observe a negative productivity *and* impact development of actual proceedings papers from 2009 and continuing into 2012. Similar trends for the productivity are visible for this document type according to WoS as well as observed by the Research Agency, Fig. 1. The productivity decline seems in particular to take place in the Medical Sciences (-66 %). Findings suggest that the decline in citation impact is caused by both purely Danish and the internationally collaborative proceedings papers (Fig. 3, right), yet mostly by the international set. Similarly, the ratios of proceedings papers vs. research articles decline from 2009, with respect to WoS indexing *and* according to the research Agency statistics, Diagram 2, left. This negative trend is also observed 2009-12 with respect to the international cooperation ratio and number of Danish institutions collaborating on research in WoS as well as the number of countries in cooperation with Denmark in the proceedings papers, Fig. 4, right.

Initially we speculated that the fractionalization in the performance indicator might have a penalizing effect on *all* collaboration patterns. However, the findings, Fig. 4, left, do *not support* this idea for the research articles. On the contrary, the international cooperation ratio as well as the mean number of Danish institutions in cooperation per article is entirely stable according to WoS indexing; and the average number of countries per article does actually *increase* from 2009. Probably the lower performance scores assigned proceedings papers combined with fractionalization applied 2008-2012 by the publication performance system has discouraged some from publishing in proceedings papers.

With respect to citation impact one observes a steady impact increase from 2001 throughout the period for the internationally collaborative research articles compared to purely Danish authored articles and a continuous increase until 2009 for international proceedings papers, followed by a radical drop into 2012, Fig. 3, right-hand side. For research articles the trend in impact is in accordance with findings by Narin et al. (1991), Glänzel (2002) and Luo et al. (2011) on higher impact observed in internationally authored articles in most areas, but in particular in biomedical, chemistry and mathematical as well as in stem cell research. The dramatic decrease in citation impact for the internationally produced proceedings papers from 2009 coincides with the lower productivity observed from the same time for proceedings papers. The number of available references turned into citations within this document type is diminishing from that year.

Research question two on major research areas

The average growth of Level 2 research articles over the four years 2009-12 is 37 %, with the Science & Technology fields showing a growth of 46 %, the Social Sciences 22 % and Medicine 16 %. This growth for Level 2 articles is substantial but below the 55 % found for the six years 2005-09 in Norway at (Sivertsen, 2010; Sivertsen & Schneider, 2012), after the introduction of their version of the performance indicator system. The Level 1 article average growth is 36 %, with the Social Sciences as the most significant (37 % growth) followed by S&T (29 %) and Medicine (24 %).

In the Social sciences it seems evident that the performance indicator from 2009 has encouraged researchers to publish in Level 1 journals rather than through proceedings papers, Fig. 6. The system assigns 1 publication point to the former whilst providing .75 points to the latter document type. A kind of 1-2 year ‘incubation time’ for researchers in S&T and the Social Sciences seems to occur prior to the acceleration of research article productivity at both levels. In Medicine researchers seem continuously to increase their article productivity without hesitation and fast to abandon proceedings papers as a research channel.

Research question three on university productivity

All in all the universities of Aalborg and Southern Denmark have stepped up their productivity since 2009 with respect to journal article production. Also Aalborg increases its proceedings paper productivity. In contrast, University of Copenhagen and University of Southern Denmark substantially drop their contributions to this type of research publications, the former university also slightly decreasing its involvement into Level 1 and 2 articles. Of the large universal universities Aarhus maintains its proportional productivity in all the three document types.

Methodological issues associated with WoS coverage

The entire set of Danish publications assigned performance scores by the Danish Research Agency is logically containing the WoS-defined set analysed in the present study. One may consequently assume that the overall trends observed in the WoS-defined set mirror the trends in the agency-defined Danish set; for a comparison, see for instance Fig. 2, left. Fig. 1 demonstrates the growth patterns in the CPCI-S and SSH combined and the equivalent share of Danish proceedings papers 2000-12 across eight data points (from Table 1). The diagram shows that 1) the two conference citation indexes decrease dramatically their coverage of that document type since 2006 and 2) similar (negative) growth trends occur for both the WoS and Agency’s Danish segments. In particular CPCI-SSH has fundamentally decreased and in 2013 only indexing 17 Danish proceedings papers. By knowing the real number of Danish publications, Fig. 5, this implies that the real number of proceedings (and anthology) papers published is far from being indexed in those two indexes, but that certain indicators, such as impact and international collaboration ratios and trends probably are valid. The proceedings paper/research article ratio scores are thus not realistic; they are too negative – although their trend pattern may very well be (Fig. 2, left). By comparing the productivity obtained from WoS with that provided by the Danish Research Agency (Forskningsstyrelsen, 2013), Fig. 5, one observes, for instance, that for 2011 the Agency stipulate the publication of 14,247 journal articles out of which WoS covers 13,238 (Table 1) with a coverage of 93 %. For proceedings papers in WoS vs. anthology plus proceedings papers given by the Agency, the coverage is only 40 % in 2011.

We may thus infer that the proceedings paper decline observed in the WoS set, although less pronounced in reality, with a high probability does take place in Medicine (-66 %) and in the S&T fields and Social Sciences (-6 %), and that the substantial growth of research articles, and continued positive national impact development detected in WoS, with great certainty

primarily is caused by high productivity and growth of *Level 2 articles* (Fig. 5), in particular published by the Science & Technology fields.

Conclusions

The publication behaviour regarding *research articles* seems positively affected by the introduction of the publication performance indicator in 2009. The indicator functions as the central accelerator for the developments of level 2 articles, in particular published by the Science & Technology fields (positive incentive), and proceedings papers (negative perception). The overall positive trends of steady publication and citation impact growth already in progress from 2001 have continued linearly, regardless the introduction of the model. From a research political perspective this is acknowledgeable. The slight drop in the productivity of proceedings papers initiated 2009 according to the Research Agency derive mainly from Medicine and to some extent from the Social Sciences where research articles at Level 1 replace proceedings papers as the most used publishing channel after 2010. Less assigned scores to proceedings and anthology papers than to journal articles evidently have effect on productivity. The decrease in the international collaboration ratio as well as in the number of Danish research institutions cooperating is with high probability caused by the performance indicator model's fractionalization mode and its perception in the research communities. The multiplication factor applied to collaborative publications seems only effective among Level 1 and 2 articles with their stable collaboration ratios – not with respect to the less valuable (in assigned scores) proceedings papers. The analysis also demonstrates an influence of the performance model on the publication patterns of some universities.

Finally, it is evident that the introduction of the publication performance indicator, which solely assigns points to the published peer reviewed publications, thus far has not introduced a 'salami-tactics' in the production behaviour in the Danish science system and a consequential decline in citation impact, as witnessed in Australia in connection with other but more simplistic point-based assessment systems (Butler, 2003; 2004).

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